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PROBLEMS OF COMPARING RURAL PUBLIC TRANSPORT POLICIES IN SASKATCHEWAN USING A CONCORDANCE ANALYSIS AND MULTI-DIMENSION SCALING PROCEDURE

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Contents

Introduction 1

1) The Rural Transportation Problem 3

2) The Saskatchewan Rural Public Transportation Policy Review: Brief Comments 9

3) Definition of the Data Matrix and Evaluation Criteria 13

4) Analysis of Policy Option Experiments: Results and Conclusions 25

References 35

Appendix 41

Abstract

This report examines the use of a formal procedure - concordance analysis and multi-dimension scaling - for comparing alternate policies to solve a transport problem in Saskatchewan. The specific problem was to select a public transport system to serve small rural communities. The data used in the study are contained within the Saskatchewan Rural Public Transportation Policy Review (1978). Six alternate policy options were defined; each refers to a size-category of rural communities that could be served. The categories were communities with populations > 100, > 150, > 200, > 300, > 400, and > 500. For each policy three administrative options and four cost criteria were provided. Experiments were conducted to provide classifications of the policy options to determine the relative attractiveness of each policy. The analysis suggests that the most appropriate policy is to serve communities with populations of at least 300. This appears to be the most cost-effective option. Comments on the data requirements of the procedure are included. The appendix gives details of a theoretical approach for determining the relative importance of criteria for use in concordance analysis.

INTRODUCTION

In recent years a variety of formal procedures have been developed to tackle the problem of selecting a best policy from a set of feasible ones. A review of a selection of this literature is presented in Massam and Wolfe (1979); Massam (1980); Massam and Askew (1982); RTAC (1978); and Hill (1973). It is the purpose of this report to consider the use of one procedure - concordance analysis and multi-dimension scaling - for comparing alternate policies for a transportation problem in Saskatchewan. This procedure uses information about alternate policies on a set of criteria in order to provide a classification of the policies. By comparing the feasible alternatives with a hypothetical best alternative, it is possible to interpret the classification and comment on the relative attractiveness of each policy. Applications of the procedure to the comparison of mass rapid transit systems in Singapore is given in Massam (1978), and to highway location problems in Ontario and France in Massam (1981, 1982).

The transport problem in Saskatchewan that will be examined in this report addresses the issue of improving the quality of accessibility to services for rural dwellers. Details of the study are given in the Saskatchewan Rural Public Transportation Policy Review (SRPTPR) (1978). We will use this study to provide a data base for our work.

Chapter 1 of this study provides a statement of transportation planning problems in rural areas. This is followed by brief remarks summarizing the Saskatchewan study. The third chapter examines in detail the data matrix and the criteria used for evaluating each alternate policy. In Chapter 4 the results of the analyses are presented. The appendix includes a discussion of the problem of assessing the relative importance of criteria used for evaluating each policy. A method is proposed to determine criteria weights using expressed preferences of individuals or groups. This method will give results which can be included with the data matrix for analysis using concordance indices and multi-dimension scaling.

Chapter 1
THE RURAL TRANSPORTATION PROBLEM

That there is a problem for transportation in rural areas has been apparent in many countries for several years. In Canada it is only recently that attention has been focussed on rural transport. Public transportation is central to the problem, although for different reasons in different countries. For example, in Britain there is a tradition of public transport in the countryside and the problem is one of declining demand. In Canada there has been little public transportation in the past, and the Saskatchewan study revealed a growing demand by communities not served at present.

However, both countries, one with declining demand, the other with increasing demand, share a common problem which is best conceptualized as an accessibility problem, derived from mobility depreciation. Mobility is "an individual's propensity or ability to travel" (Blowers 1978, 50), and accessibility incorporates this notion of personal mobility. Accessibility as a concept is discussed fully by Moseley et al. (1977, Ch. 5), and they conclude that it represents the opportunities available to be able to undertake an activity; it is thus a function of location and mobility and is equally applicable to places and persons. More recently we must recognize the role of telecommunication systems in allowing individuals at isolated locations to participate in the sharing of information without physical movement. Mobility and

location should not be dealt with in isolation, but in association with the central purpose of transportation, that is, movement to residential, employment and service activity locations. The concern here is specifically with transportation, and so it is pertinent to consider the mobility of rural dwellers.

Fuller and Wolfe (1980) identify several causes of problems for mobility in rural areas. The increased separation of workplace and home is dominant. It is due ultimately both to the decrease in labour-intensive farming methods (requiring a local labour force), and to the influx of exurbanite commuters into rural areas. Although car ownership rates are very high in the countryside, the household car will invariably be used by the chief wage earner, leaving the rest of the family carless and marooned during the working day.

Allied to the spatial distinction between home and work is the increasing trend towards centralization in the provision of service facilities, which often results in the need for journeys outside the settlement for even the most basic of supplies. Centralization is necessary to achieve economies of scale, and low population densities mean that often one facility must serve several villages, necessitating a large amount of travel. A full discussion of the literature on providing services to rural dwellers is given in Askew (1981).

There is a certain paradox to the relationship between mobility and location in that it is precisely the general increase in personal mobility that caused

the spatial differentiation of home, work, and services. The result has been an increased dependence on transport by rural dwellers, who previously had little need to travel because their community was self-sufficient and could cater to all their needs. A consequence of this increased dependence on what, by force of situation, must be personal transport, is an increasing gap in mobility (and accessibility) between the "haves" and the "have nots." The "having" refers to the ownership of, or at least access to, a car, and in Canada the auto-dependent transportation system causes great hardship to the "have-nots." This group of people are referred to as the **mobility deprived** by Moseley et al. (1977), and the **transportation disadvantaged** by Fuller and Wolfe (1980).

The have-nots are the problem group when considering rural transportation and, being a minority, solutions are difficult. The Saskatchewan study is responding by providing an improved rural bus system. Because it is increasingly difficult to provide a suitable service without creating a loss, the provincial government has decided to institute a subsidized service, and the purpose of the SRPTPR study was to review the situation in order to decide on the best course of action.

However, it is worth noting that Fuller and Wolfe (1980) conclude from their study of Southwestern Ontario that with the high costs, and special needs of the disadvantaged groups, conventional public transport is not a viable solution. They propose a system of minibuses and cars based on a formal volunteer driver organization in the form of a mobility

club (Yukubowsky and Fichter 1974). The Saskatchewan study proposes to use small buses, vans, and cars.

Some guidance on unconventional public transportation systems can be found in Britain, where a series of experimental schemes (known as RUTEX) have been run and are still being undertaken. The term unconventional generally refers to a system which shows some of the attributes of small vehicles, voluntary labour, flexible timetabling and flexible routing. Sixteen schemes undertaken and administered by the Transport and Road Research Laboratory (TRRL) have been in operation since 1977. They are described by Milefanti (1978). The public National Bus Company (NBC) has also considered unconventional schemes which are discussed in Glassborrow (1978). They include demand-actuated services (e.g., dial-a-ride) and multi-purpose bus journeys (e.g., passengers travelling on school, work and postal buses). The results are generally encouraging, although the apparent advantages of small buses are a fallacy, as labour costs are as high as 70 percent of the total operating costs. The importance of public ownership needs to be emphasized, because a monopolistic operator is able to cross-subsidize the rural routes with profits from the urban routes. This is often forgotten when calls for deregulation are made.

Given the dominance of the automobile in Canada, car-pooling and car-sharing could be useful alternatives if more formally organized. A proper system of advertising lifts, or volunteer driver schemes, could be quite easy to set up in a small community. Financial help could be provided by the government in

lieu of a public bus system, in the form of subsidies on car tax or gasoline, and allowances made in the insurance arrangements.

To summarize, some causes and possible solutions to the rural transport problem have been given. It must be borne in mind that the problem exists for a specific group of rural dwellers, the carless, and that solutions should be geared to their needs, both for efficiency of provision and for a satisfactory service.

Chapter 2

THE SASKATCHEWAN RURAL PUBLIC TRANSPORTATION POLICY REVIEW: BRIEF COMMENTS

The Saskatchewan Rural Public Transportation Policy Review (SRPTPR) was carried out in 1978 in response to an increasing demand from rural communities in Saskatchewan for a basic level of transportation. The province already has, by Canadian standards, a high level of bus service in rural areas, as in the past it has aimed at trying to provide a basic means of transportation for everyone. The existing service is provided mainly by the Saskatchewan Transportation Company (STC), a Crown corporation, which operates a cross-subsidization policy. The STC is supplemented by the Community Transportation Services (CTS), a subsidiary of the STC, which was established in 1975 as a partial response to the aforementioned request. In 1976-77, however, due to declining ridership numbers and increasing costs, the ability of the STC to cross-subsidize unprofitable with profitable routes diminished, and the STC incurred a loss of $25,000. The government Finance Office was forced to consider a subsidization of the bus service if two objectives were to be met: to maintain the STC as a viable commercial entity; and to respond to the growing demands for public bus service in rural Saskatchewan. It became apparent that if the STC was to extend its coverage of rural areas, then the regular buses were inappropriate modes of transportation, and it would be more suitable to use small vans or cars. Also the new routes would be feeder

lines or extensions to local routes to increase the existing network density.

At this point it seemed necessary to the government of Saskatchewan to undertake a comprehensive policy review before proceeding with implementing new services. The aims of the policy review are listed in table 1. From this, a series of specific study objectives, which are given in the report, were drawn up, and a set of transportation objectives, classed according to whether they are for the users or for the providers (the government). Given this brief, the Steering Committee developed and evaluated a set of policy options with the following major objectives in mind:

a) to maximize the provision of services on an equitable basis;

b) to maximize the local community involvement;

c) to minimize government costs;

d) to facilitate programme administration.

The alternatives were developed specifically considering the community size, frequency of service, express services, whether the four CTS routes should be included, and which agency should be responsible for the administration of the programme. The policy options were formulated according to the population of communities to be served, grouping communities by population size. The frequency of service was set at two days per week, as the extremes of one-and-five days service per week were thought to under- and over-

Table 1

THE AIMS OF THE POLICY REVIEW

(a) To determine the outer bounds of rural centres and population which can be realistically served by some form of public or community-organized transportation service;

(b) To estimate the financial costs of providing the above service;

(c) To develop a financial and administrative arrangement which clearly defines the role of STC, communities and the government in responding to these demands; and

(d) To articulate a general operating policy with sufficient flexibility to respond to the unique circumstances of individual small communities who wish to establish some form of public service for their residents.

Source: adapted from SRPTPR, p. 10.

provide respectively. An express service may be introduced during the seeding and harvesting seasons. It was decided that the best arrangement for administering the programme would be to have the Department of Highways and Transportation (DHT) administer it via a contract with the local transit authority. The decision was reached because it would give the financing body (the DHT) firmest control while maximizing local involvement. It was felt to be preferable to keep the programme separate from the STC operations due to the subsidy arrangements. The status of the CTS routes, their financing and administration, was also raised in the analysis, and this is discussed later.

The SRPTPR study includes data on the costs and revenue for each option and presents a series of tables to help in the evaluation of the alternatives. The conclusions and recommendations are given, followed by the procedures for implementing and monitoring the programme.

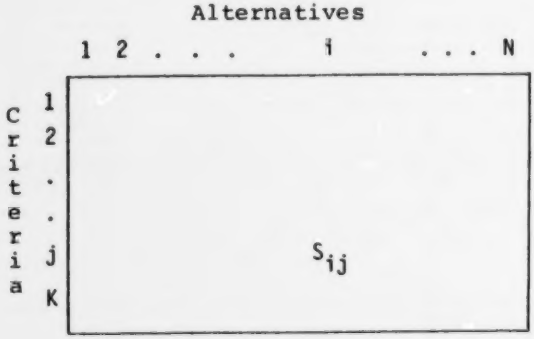
Chapter 3

DEFINITION OF THE DATA MATRIX AND EVALUATION CRITERIA

It is the purpose of this section to develop a data matrix of the form shown in figure 1.

Figure 1

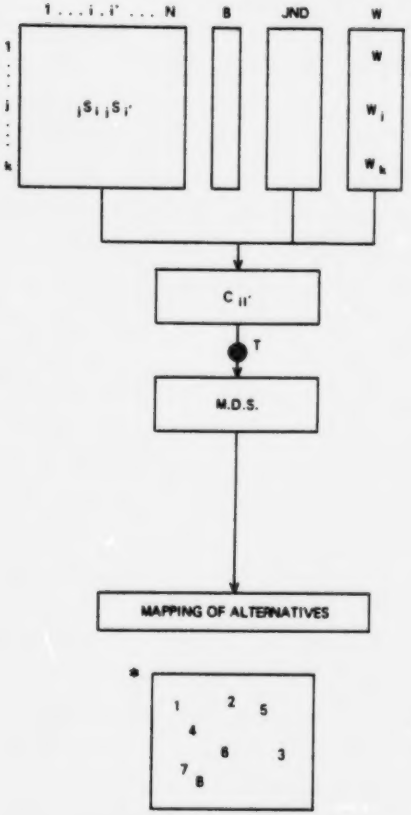
GENERAL DATA MATRIX



This matrix offers N alternate policies and for each one, K criteria are used to provide a set of scores. The score for policy i on criterion j is shown as S_{ij}. A matrix of this form together with a set of weights, one for each criterion, is the basic input to the concordance analysis and multi-dimension scaling procedure. A schematic flow diagram summarising the procedures is shown in figure 2. A procedure for determining criteria weights is given in the appendix.

The SRPTPR provided a large amount of data, and there are various ways in which they can be presented. The policy options were formulated according to

Figure 2
SCHEMATIC FLOW DIAGRAM OF CONCORDANCE ANALYSIS AND MULTI-DIMENSION SCALING PROCEDURE [1]



1 . . . j . . . k	criteria
1 . . . i . i' . . N	alternatives
$_jS_i$	score for alternative i for criterion j
B	benchmark, ideal alternative
JND	Just Noticeable Difference, threshold
W_j	weight of criterion j
$C_{ii'}$	concordance index between alternatives i and i'
T	an arithmetic transformation is necessary to prepare $C_{ii'}$ values for input to M.D.S.
M.D.S.	multi-dimension scaling algorithm to produce a map of the (N+B) alternatives
*	typical example of a two dimension map, N=7, plus B (BEST)

1 Complete details in Massam (1980) Chapter 6, pp. 237 to 278.

population target groups as follows: settlements of over 100 population; over 150; over 200; over 300; over 400; over 500. Each policy option was designed to serve communities of a certain minimum size, and routes were established between communities eligible on this criterion. In carrying out the study, a set of transportation objectives were developed at the beginning and reduced to four major ones, as discussed earlier. A wide range of evaluation criteria were proposed, that is, operational forms of the objectives, and they are given in table 2. In practice, a set of seven were actually used and a description of these is now given.

Number of Passengers - the predicted ridership was calculated by means of a regression analysis of data collected on three CTS routes. After considering several independent variables, the only significant one was found to be the population of a community.

Number of Eligible Communities - an eligible community is one which at present is unserved by the public transportation system, and which is of a size within the range of the policy option target population.

Percentage of Eligible Communities Served - self-explanatory.

Total Number of Communities Served - this figure includes both the eligible communities and those communities served by the existing service.

Total Vehicle Operating Costs - these were calculated by combining estimates of daily vehicle mileage, costs per mile, and number of days service per year. Table 3 gives the breakdown of the operating costs per mile and table 4 gives the total daily route miles for each option.

Table 2

EVALUATION CRITERIA

(a) Point of View of Users:

i) number of communities in target group
ii) percentage of target group served
iii) total number of communities served
iv) number of routes that use:
- small buses
- vans
- automobiles
v) percentage of routes providing interline connections
vi) directness of routes
- ratio of system mileage to automobile mileage
- ratio of system times to automobile times
vii) estimate of system flexibility
viii) estimate of goods movement service

(b) Point of View of Providers:

i) total ridership
ii) total passenger revenue
iii) total goods revenue
iv) total direct operating costs
v) ratio of passenger revenue to direct operating costs
vi) ratio of total revenue to direct operating costs
vii) total indirect costs
viii) total system costs
ix) total system deficits
x) total deficit per passenger
xi) vehicles required:
- small buses
- vans
- automobiles
xii) vehicle productivities
- passengers per small bus
- passengers per van
- passengers per automobile
xiii) percentage of routes where vehicle productivity is greater than one passenger per vehicle hour
xiv) administrative simplicity
xv) operational feasibility

Source: SRPTPR, pp. 17-18.

Table 3

TOTAL DIRECT OPERATING COSTS PER MILE

Cost Components	Costs For Vans Cents/Mile	Costs For Standard Autos Cents/Mile
Fuel Costs	7.8	6.9
Tires	1.1	1.1
Repair and Maintenance	3.0	2.3
Depreciation	8.0	7.0
Labour Costs	15.0	15.0
Licence and Insurance	0.7	0.7
Package Policy	1.0	1.0
Cost of Money	4.0	4.0
	40.6	38.0
Profit @ 10%	4.0	3.8
	44.6	41.8
Rounded =	45.0	42.0

Source: SRPTPR, Appendix 4, p. 6.

Table 4

TOTAL DAILY ROUTE MILES BY VEHICLE TYPE FOR EACH OPTION

CTS Alternatives \ Policy Option	> 100	> 150	> 200	> 300	> 400	> 500
Program Replaces CTS (CTS runs are dropped)	7 090 T 740 V	5 805 T 290 V	3 862 T 290 V	2 265 T 190 V	1 245 T 150 V	890 T
CTS Retained and Financed by STC (CTS run excluded from program)	6 430 T 460 V	5 105 T	3 472 T	1 945 T	1 135 T	640 T
CTS Retained and Financed by Program (CTS runs financed by the program)	6 430 T 2 044 V	5 105 T 1 584 V	3 472 T 1 584 V	1 945 T 1 584 V	1 135 T 1 584 V	640 T 1 585 V

T = Taxi
V = Van

Source: SRPTPR, Appendix 4, p. 7

Total Operating Costs - these represent the sum of the vehicle operating costs and the administration costs. Administration costs are based on the assumption that the DHT would administer the programme; a set of costs for the STC administering the programme were also calculated. This second administration possibility was rejected on the grounds that the new programme should be kept separate from the existing service.

Total Net Operating Costs - these were calculated by subtracting the revenue from the total operating costs. Revenue was estimated from an average per capita figure derived from existing CTS data. In addition, revenue from express services was estimated at 25 percent of the passenger revenue.

The impacts also varied according to the exact format of the programme, that is, how CTS routes were treated. Three alternatives were proposed, and these were incorporated both as variations to the criteria, and as policy options. The alternatives were:

1) CTS routes are retained, but not financed by the programme (operated and financed by the STC).

2) CTS routes are retained and financed by the new programme.

3) Only the eligible CTS centres are served by the programme (the programme replaces CTS routes).

The DHT administers the programme in all three alternatives.

From the set of six policy options and seven criteria (sub-divided according to administration

variables), the data matrix shown in table 5 can be constructed. The policy options are devised such that they consider only one aspect of distribution, that is, size of settlement. It is commonly found, due to either economies of scale or the historical geography of a region, that smaller settlements are not always located on the major routeways. By formulating the policy options according to the population of communities at present unserved, the benefits (criteria A-D) can be directly traded against the costs (criteria E-G). There is the assumption of unlimited government funding, but the final recommendation did set the budget at $256,000.

A complete analysis should enable one to consider distributional aspects. This can be achieved by forming social groups (defined by mobility, income, age or any other relevant criterion) as impact categories. Thus if the evaluation criteria (which represent policy objectives) are disaggregated by social group, the impacts on groups can be seen more easily. It is also possible to examine the temporal dimension of impacts. The new impact matrix which takes account of the distributional effects has the general form shown in figure 3. Lack of empirical data for the Saskatchewan study prevents the determination of the S_{ij} values. It is suggested that future practical exercises attempt to include such data.

It is possible to evaluate options with the specific interests of a particular group under consideration by weighting that group accordingly. This

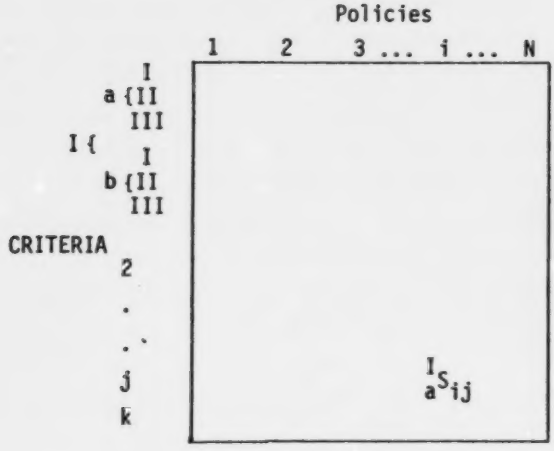
Table 5

BASIC DATA MATRIX

Criteria	Admin. Alternatives	Options 1 ≥100	2 ≥150	3 ≥200	4 ≥300	5 ≥400	6 ≥500
A	1	17200	14200	12000	7600	5000	3700
	2	23900	20800	18700	14200	11700	10300
	3	22900	19200	16300	11000	7000	4700
B	1	109	68	41	21	11	6
	2	139	88	55	31	17	8
	3	139	88	55	31	17	8
C	1	100	100	100	100	100	100
	2	98	98	100	100	100	100
	3	98	98	100	100	100	100
D	1	117	84	60	31	17	11
	2	176	143	114	85	72	65
	3	164	119	87	48	31	19
E	1	302400	223000	151600	85000	49600	28000
	2	376600	297200	225800	159000	123800	102000
	3	344400	267200	182400	108000	61400	38800
F	1	449200	341000	251700	154000	104400	77300
	2	546900	438700	345800	256000	201500	174200
	3	515700	405000	295200	187500	122300	92400
G	1	422300	317100	232100	142000	97300	71400
	2	479400	374600	286100	198000	154500	128500
	3	475900	369600	265300	167100	110200	83400

Figure 3

IMPACT MATRIX SHOWING DISTRIBUTIONAL EFFECTS



$^{I}_{a}S_{ij}$ impact of policy i using criterion j on social group a during time period I

approach can be used to study the distribution of costs and benefits. The Saskatchewan report did emphasize that there was to be no disaggregation or assignment of costs among communities. "It did not recognize the individual community's ability to pay nor would it be equitable, since there are at the moment many communities in rural Saskatchewan which receive bus service at no cost to them. To require the communities in the unreserved category to make a contribution would be discriminating on a geographical

basis" (SRPTPR, p. 21). An alternative to disaggregating the criteria by social groups is to formulate criteria that reflect the interests of the group. These could be in the form of standards, described on a cardinal scale, which are defined by a certain minimum standard. For example, there could be an objective of serving people without access to cars; this would be an evaluation criterion. Or there could be some limit on the length of journey to a particular place, reflecting other commitments in a person's lifestyle, such as an individual's need to take care of children, and this could be built into the matrix as an impact category.

The point being made here is that if one was to restrict the evaluation to a cost-effectiveness analysis, due simply to the presentation of the data, one would be missing the possibilities of a far more comprehensive evaluation, and the opportunitiies of considering in depth aspects of equity. The fact that the original study found it necessary to reduce the 23 original evaluation criteria to 7 summary criteria indicates that there are more data available than were finally used. The rationale for reducing the data set from 23 to 7 is not provided in the original study.

Chapter 4

ANALYSIS OF POLICY OPTION EXPERIMENTS: RESULTS AND CONCLUSIONS

In order to apply the procedure shown in figure 2 to the analysis of data in table 5, it is necessary to standardize the measurements for each option. Analysis of the raw data will yield spurious results because of the way the options have been defined. Each option is fundamentally different in terms of the costs to provide, and the benefits which are generated. The analytical task is, therefore, to offer a cost-effectiveness approach and to seek to classify the options in these terms. For this particular problem, to seek to classify the options either in terms of minimum costs or maximum benefits is not a helpful way to proceed. The latter would yield option 6 as the most preferred, whereas the former suggests that option 1 is the best.

Table 6 presents a set of four criteria for each of the six options, and for three different administrative alternatives. The costs are calculated per passenger. A series of four experiments using these data were conducted. Details of the experiments are provided in table 7.

Results showing the orders of the options are shown in table 8. for each experiment two orders were derived, one using the row sum scale (RSS) and the other using the multi-dimensional scaling (MDS)

Table 6
NEW DATA MATRIX

Criteria	Admin. Alternatives	Options 1 ≥100	2 ≥150	3 ≥200	4 ≥300	5 ≥400	6 ≥500
I	1	17.6	15.7	12.6	11.2	9.9	7.6
	2	15.8	14.3	12.1	11.2	10.6	9.9
	3	15.0	13.9	11.2	9.8	8.8	8.3
II	1	0.8	0.8	0.8	0.9	1.1	1.3
	2	0.7	0.7	0.6	0.6	0.6	0.7
	3	0.7	0.7	0.7	0.7	0.9	1.1
III	1	26.1	24.0	21.0	20.3	20.9	20.9
	2	22.9	21.1	18.5	18.0	17.2	16.9
	3	22.5	21.1	18.1	17.0	17.5	19.7
IV	1	24.6	22.3	19.3	18.7	19.5	19.3
	2	20.1	18.0	15.3	13.9	13.2	12.5
		20.8	19.3	16.3	15.2	15.7	17.7

I = Vehicle Operating Costs per Passenger ($)
II = Administration Costs per Passenger ($)
III = Total Operating Costs per Passenger ($)
IV = Net Operating Costs per Passenger ($)

Table 7

DETAILS OF EXPERIMENTS

Experiment	Benchmark	Criteria	Administrative Alternative
1	Best	1 - 4	All
2	Best	1 - 4	1
3	Best	1 - 4	2
4	Best	1 - 4	3

Table 8

NEW DATA EXPERIMENTS - RESULTS

	1		2		3		4	
	RSS	MDS	RSS	MDS	RSS	MDS	RSS	MDS
Best	7	7	7	7	7	(7 6)	7	7
	4	(4 3)	4	4	6		4	4
	5		6	2	5	(3 4 5)	5	2
Options	6	6	(3 5)	6	4		3	6
	3	5		1	3		6	(5 1 3)
	2	(1 2)	2	(3 5)	2	(2 1)	2	
Worst	1		1		1		1	
Index of Agreement	.952		.976		1.000		1.000	
Kruskal's Stress		.118		.001		.001		.041

output.[1] For each order a measure of the correspondence with the basic data is given. For the RSS the measure is the index of agreement, and for the MDS the measure is Kruskal's stress coefficient. If the latter takes on a value of zero and the former a value of 1.0, the correspondence is perfect (full details of RSS, MDS, and the measures are given in Massam (1980, Chapter 6). In the table, tied ranks are shown by parentheses. It appears that if there is no clear preference for any of the three administrative alternatives, then overall, policy option 4 is the best, as it is most similar to the best benchmark. This benchmark is defined as option 7. Option 4 is also the preferred one for administrative alternatives 1 and 3. However, if administrative alternative 2 is preferred, then the best option appears to be 6. Options 1 and 2 are consistently among the least preferred.

A different way to consider the policy options is to reorganize the data in table 6 to present 18 policy options and four criteria. This table is shown as table 9. The order of the best and worst six options is shown in table 10. The index of agreement is 0.732, and Kruskal's stress is 0.124. The latter is for a two-dimension map. Among the six best policy options we find 11, 12, 14 and 17. From this we can

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[1] One-dimension MDS solutions are used. Given that $K < 0.15$ for each experiment, there is no need to use higher dimension output.

Table 9

Criteria/ Admin. Alternative	Options																	
	1 1	1/2 2	3 3	4 1	2/5 2	6 3	7 1	3/8 2	9 3	10 1	4/11 2	12 3	13 1	5/14 2	15 3	16 1	6/17 2	18 3
I	17.6	15.8	15.0	15.7	14.3	13.9	12.6	12.1	11.2	11.2	11.2	9.8	9.9	10.6	8.8	7.6	9.9	8.3
II	0.8	0.7	0.7	0.8	0.7	0.7	0.8	0.6	0.7	0.9	0.6	0.7	1.1	0.6	0.9	1.3	0.7	1.1
III	26.1	22.9	22.5	24.0	21.1	21.1	21.0	18.5	18.1	20.3	18.0	17.0	20.9	17.2	17.5	20.9	16.9	19.7
IV	24.6	20.1	20.8	22.3	18.0	19.3	19.3	15.3	16.3	18.7	13.9	15.2	19.5	13.2	15.7	19.3	12.5	17.7

Table 10

ORDERS OF OPTIONS FROM TABLE 9

RSS Best	MDS Benchmark
19	19
14	11
17	17
12	14
11	(12
8	15
15	16)
13	1
7	(10)
3	7
2	(3
4	2
1	4)

infer that administrative alternate 2 appears to be the most preferred. It seems clear that policy options to serve communities in categories 1, 2 and 3, namely >100: >150: >200 are least attractive on the basis of this analysis.

This study has attempted to show how a general method for classifying policy options can be applied to the practical problem of comparing alternate public transport options for rural Saskatchewan. The data included in the analysis must be presented in standardized; units in order to consider the relative effectiveness of each option. Of the seven criteria presented in the SPRTPR only four could be standardized, thus the results of the analysis are based upon only these criteria. Two ways of presenting a policy impact matrix have been used.

Prior to making a final recommendation on the merits of each policy option, it would be helpful to include in the impact matrix a more complete set of data, for example, information on the distribution of benefits and costs among different income groups, communities and regions of Saskatchewan. For these reasons we would recommend that, as a general practice, a matrix of the form shown in figure 3 be prepared. The analysis presented here assumes that each criterion is equally important. A sensitivity study of the effects of modifying the weights on the criteria should be included. A procedure for determining these weights is given in the Appendix.

The conclusions of the SRPTPR suggest that first administrative alternate 1 be recommended, that is, CTS routes be financed by STC and not financed by the programme. Second, that communities of size 200 or greater be served (thus excluding communities in categories 1 and 2: > 100 people and > 150 people respectively), and third, the maximum annual cost be in the order of $252,000 (1978 dollars).

On the basis of the analysis presented here we conclude that communities of 300 or greater should be served, and that administrative option 2 appears to be the most cost-effective. The cost of this option (from table 5) would be of the order of $200,000.

REFERENCES

Askew, I. 1981. "A Model for Generating and Evaluating Alternative Location Strategies for Services in Rural Areas of Britain." M.A. Research Paper, York University, Toronto.

Blowers, A. 1978. "Future Rural Transport Policy and Finance." In Rural Transport and Country Planning (ed. R. Cresswell). Leonard Hill, Glasgow.

Fuller, A. and Wolfe J. 1980. "Rural Mobility Problems and Solutions: An Ontario Case Study." Paper presented at the annual conference of the Association of American Geographers, Louisville, Kentucky.

Glassborrow, D.W. 1978. "Rural Bus Services - An Assessment of Current Experiments." In Rural Transport and Country Planning, (ed. R. Cresswell). Leonard Hill, Glasgow.

Hill, M. 1973. Planning for Multiple Objectives: An Approach to the Evaluation of Transportation Plans. Regional Science Research Institute, Monograph Series No. 5, Philadelphia.

Massam, B.H. 1978. "The Search for the Best Alternative Using Multiple Criteria: Singapore Transit Study." Economic Geography, 54(3), pp. 245-53.

Massam, B.H. 1980. Spatial Search: Applications to Planning Problems in the Public Sector. Pergamon Press, Oxford.

Massam, B.H. 1981. "The Search for the Best Route," Frazier, J.W. and Epstein, B.J. (eds.). Proceedings of Applied Geography Conferences, Vol. 4, pp. 23-33.

Massam, B.H. 1982. "The Search for the Best Route: An Application of a Formal Method Using Multiple Criteria," Sistemi Urbani, 1, pp. 181-192.

Massam, B.H. and Askew, I. 1982. "Methods for Comparing Policies Using Multiple Criteria: An Urban Example." OMEGA: The International Journal of Management Science. Vol. 10, No. 2, pp. 195-204.

Massam, B.H. and Wolfe, R. 1979. "The Multicriteria Choice Problem and Plan Evaluation: A Test of a Method," Canadian Journal of Regional Science, II, I, pp. 11-24.

McAllister, D.M. 1980. Evaluation in Environmental Planning. M.I.T. Press, Cambridge.

Milefanti, D.C. 1978. "Government Rural Transport Experiments 1977." In Rural Transport and Country Planning (ed. R. Cresswell). Leonard Hill, Glasgow.

Moseley, M.J. et al. 1977. Rural Transport and Accessibility. Final Report to the Department of the Environment. Centre of East Anglia Studies, University of East Anglia, Norwich.

Roads and Transportation Association of Canada. 1978. Review and Assessment of Transportation Systems Evaluation Techniques in Canada. Report of the Technical Committee on Systems Analysis and Evaluation for the Policy Committee (RTAC).

Saaty, T.L. 1980. The Analytic Hierarchy Process. New York: McGraw-Hill Ryerson Ltd.

Transportation Agency of Saskatchewan. 1978. Saskatchewan Rural Public Transportation Policy Review. Operations Planning Branch, Transportation Agency of Saskatchewan.

Yukubowsky, R. and Fichter, D. 1974. Mobility Club: A Grass Roots Rural and Small Town Transport Centre. Preliminary Research Report 69, New York, Department of Transport.

Appendix

A PROCEDURE FOR DETERMINING THE RELATIVE IMPORTANCE OF CRITERIA

In order to use a data matrix of the style shown in figure 1 or 3 to calculate a concordance matrix, prior to analysis using multi-dimension scaling, it is necessary to assign weights to each criterion. A schematic flow diagram of the algorithm for classifying alternate policies using concordance analysis and multi-dimension scaling is shown in figure 2. Full details are given in Massam (1980: Chapter 6) and will not be repeated here. The purpose of this appendix is to present a method for determining weights to be assigned to each criterion. For the purposes of the work reported earlier, it was assumed that each of the four criteria were equally important, and thus a weight of 0.25 was assigned to each. It is conventional that the sum of the weights be 1.0.

A method for deriving weights using expressed preferences follows an approach used by Saaty (1980). The starting point is to construct a positive reciprocal matrix from a set of pairwise comparisons of criteria. The comparisons could be made by an individual or represent the consensus of a group. Saaty suggests that if a pair of criteria are judged to be equally important then a score of 1.0 be assigned in the appropriate cell in the matrix. The degree of dominance of one criterion over another can be represented by a higher number. Saaty has

suggested that a suitable range lies between 1.0 and 9.0. If all pairwise comparisons for a set of criteria, I, II, III and IV, yield values of 1.0, the positive reciprocal matrix is as shown in figure 4.

Figure 4
POSITIVE RECIPROCAL MATRIX

	I	II	III	IV
I	1	1	1	1
II	1	1	1	1
III	1	1	1	1
IV	1	1	1	1

The principal eigenvector of this matrix is (1, 1, 1, 1), and if these values are normalized they become (0.25, 0.25, 0.25 and 0.25), that is, each value is divided by the sum of the values. The normalized values are referred to as priority values by Saaty. They can be considered as representing the relative importance of criteria. As can be seen in this example, if all pairs are considered to be equally important, the weights for the criteria are equal.

In figure 5 another possible positive reciprocal matrix is given.

Figure 5
A POSITIVE RECIPROCAL MATRIX

	I	II	III	IV
I	1	5	6	7
II	1/5	1	4	6
III	1/6	1/4	1	4
IV	1/7	1/6	1/4	1

(Modified after Saaty 1980, p. 19.)

In this instance criterion I is stongly more important than criterion II, and is assigned a value of 5. It follows that II when compared to I is 1/5 as strong. Details of the scale recommended by Saaty are given below.

The "agreed upon" numbers are the following. Given elements A and B; if

A and B are equally important, insert 1
A is weakly more important than B, insert 3
A is strongly more important than B, insert 5
A is demonstrably or very strongly more important than B, insert 7
A is absolutely more important than B, insert 9

in the position (A,B) where the row of A meets the column of B.

An element is equally important when compared with itself, so where the row of A and column of A meet in position (A,A) insert 1. Thus the main diagonal of a matrix must consist of 1's. Insert the approporiate reciprocal 1, 1/3, ..., or 1/9 where the column of A meets the row of B, i.e., position (B,A) for the reverse comparison of B with A. The numbers 2, 4, 6, 8 and their reciprocals are used to facilitate compromise between slightly differing judgments. (Saaty 1980, p. 18.)

The priority vector of the matrix shown in figure 5 is (0.61, 0.24, 0.10, 0.15).

One of the features of the information in this type of matrix is that intransitivities can occur. There are a variety of ways of measuring the consistency of the information in a matrix to establish the number of intransitivities. One of the methods has been proposed by Saaty using a consistency ratio (CR). Given n criteria in a matrix a consistency index (CI) is defined as:

$$(\lambda_{max} - n) / (n-1)$$

where λ_{max} is the principal eigenvalue. This index can be compared to one derived from a randomly generated reciprocal matrix using the nine-point scale. This latter index is the random index (RI). The consistency ratio is defined thus:

$$CR = CI/RI.$$

As CR approaches zero the degree of consistency becomes higher. The value for CR for the matrix shown

in figure 5 is 0.14, indicating a fairly good measure of consistency. Saaty suggests that a value of 0.10 presents a satisfactory upper limit. No evidence is provided for this assertion. Clearly, an inferential framework needs to be developed to interpret the value.

A set of positive reciprocal matrices can be derived using preferences of different individuals or groups. The weights of criteria and the CR can be calculated for each. The effect that altering the weights has on the classification of alternate policies can be studied. As part of the search for the most preferred policy, this type of sensitivity is appropriate.